

Applicant notes that the election of species is for the purpose of prosecution on the merits, and that Applicant will be entitled to consideration of claims to additional species upon allowance of a generic claim. It is understood that if the claims of the elected Species 1 are found allowable over the prior art, the Examiner will expand the search to include other species — i.e., original Species 2-32, and secondary Species 1-4 and 6-10.

Preliminary Amendment. Prior to substantive examination, Applicant requests that the following amendments be made to the above-referenced application.

IN THE IN THE SPECIFICATION

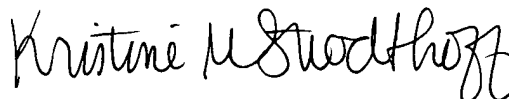
Please amend page 2 of the specification as shown in the attached replacement sheet 2 submitted in the Revised Format showing the requested changes.

REMARKS

The specification has been amended at page 2, line 18, to correct a typographical error ("The dielectric layer is ~~exposing~~ exposed to a...").

Applicant believes that the claims are in condition for allowance, and notification to that effect is respectfully requested.

Respectfully submitted,



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budgets such as DRAMS or flash devices due to the loss of integrity of the gate oxide as well as the loss of transconductance due to the proximity of nitrogen to the gate oxide-silicon interface.

Another conventional method to incorporate nitrogen into the gate oxide layer is to form a composite gate dielectric layer comprising a silicon nitride layer and an oxide layer. An issue with forming such a composite gate oxide is that the interface between the silicon nitride and oxide layers typically requires rigorous post-treatment processing to eliminate potential sources of charge trapping. In addition, composite gate dielectrics that comprise nitride and thermal oxides have limitations due to the total effective oxide thickness that can be achieved due to poor nucleation of nitride on oxide. This requires the formation of a relatively thick nitride layer resulting in an overall effective oxide thickness that is higher than that which is considered as usable.

Thus, a need exists for a nitride barrier layer that avoids such problems.

SUMMARY OF THE INVENTION

The present invention provides methods for forming a nitride barrier film layer useful in fabrication of semiconductor devices such as gate structures. The nitride layer is particularly useful as a barrier to boron diffusion into an oxide film.

In one aspect, the invention provides methods for forming a nitride barrier layer over a dielectric (oxide) substrate. The dielectric layer is ~~exposing~~ exposed to a silicon-containing species under low partial pressure, high vacuum to nucleate the surface of the dielectric layer and deposit a thin layer of silicon, which is then exposed to a nitrogen-containing species to nitridize the silicon and form a silicon nitride barrier layer. The silicon-containing species can be deposited, for example, by plasma enhanced chemical vapor deposition, low pressure chemical vapor deposition, rapid thermal chemical vapor deposition, among other processes. The silicon layer can comprise polysilicon or amorphous silicon. In an embodiment of the method, an oxide layer is irradiated with a silicon-containing species at a low partial pressure of about 10^{-2} Torr (10 mTorr) or less to selectively deposit a thin layer of silicon onto the oxide surface, preferably about 10 to about 20 angstroms thick. The silicon layer can then be thermally annealed in a nitrogen-containing species at a preferred temperature of about 700°C. to about 900°C., or exposed to a plasma source of nitrogen to nitridize the silicon. The plasma nitrogen can be produced, for example, by a